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WORLD MARITIME UNIVERSITY

Shanghai, China

**RESEARCH ON XIAMEN PORT NETWORK
LAYOUT FROM THE PERSPECTIVE OF
HARBORS AND INLAND PORTS LINKED
DEVELOPMENT**

By

ZHENG YIJUN

China

A research paper submitted to the World Maritime University in partial Fulfilment of
the requirements for the award of the degree of

MASTER OF SCIENCE

(INTERNATIONAL TRANSPORT AND LOGISTICS)

2015

DECLARATION

I certify that all the material in this research paper that is not my own work has been identified, and that no material is included for which a degree has previously been conferred on me.

The contents of this research paper reflect my own personal views, and are not necessarily endorsed by the University.

(Signature): Zheng Yijun

(Date): 2015-6-30

ABSTRACTS

Title of Research paper:

**Research on Xiamen Port Network Layout from the Perspective of Harbors and
Inland Ports Linked Development**

Degree: **MSc**

The research paper is a study of Xiamen port network layout from the perspective of harbors and inland ports linked development.

In this thesis, the case study of Xiamen has been made to find out the relationships between harbor and inland ports. Also, the questionnaires have been made and the feedbacks have been analyzed in order to draw full pictures about the real condition of the linked of harbors and inland ports – not only the full picture of Xiamen, but also of China. Through these two pictures, we can easily know the real network layout nowadays. Then, Xiamen has been taken as an example, using PEST method to analyze the merits which Xiamen port has, and using AHP model to select which hinterland of Xiamen should be given priority to develop. And at last, according to the reality, the solutions about how to develop the network of harbor and hinterland of Xiamen have been given. From the thesis we can see, the development of network of Xiamen port and hinterlands is not only a challenge, but also a chance to increase the city's maritime reputation, and a complete network can help Xiamen itself develop to be an international port city.

KEYWORDS: Xiamen port, harbor, network, hinterland, inland port, development

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LIST OF ABBREVIATIONS

LCL	Less than a container load
ITTs	Intra terminal transfers
ETTs	External terminal transfers
ETA	Estimated time of arrival

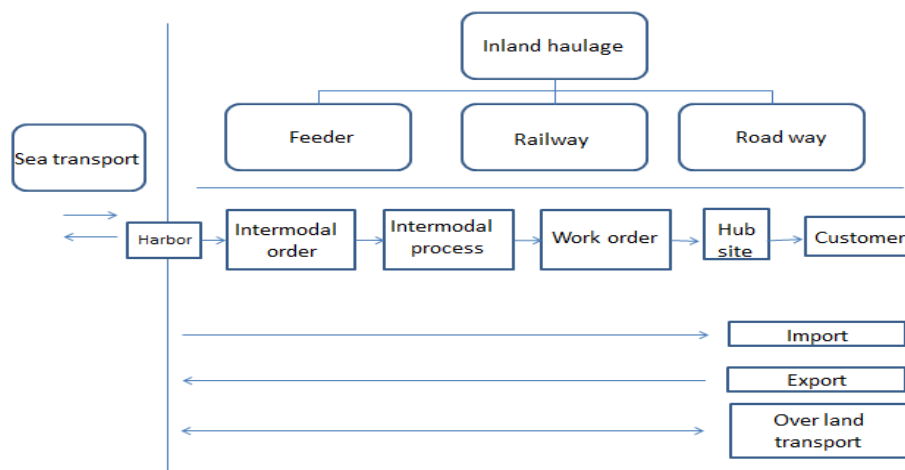
1. Introduction

1.1 Research Background

Intermodal is the transportation of containerized door-to-door shipments that have to use different ships and/or different means of transportation (aircraft, rail, ships, trucks, etc.) from origin to destination.

Since 1990s, “inland port” became popular in the report of supply chain and logistics. Inland port considered to be a distributing center in the logistics and transportation net, it usually connect with harbors, and it is an important link of the containers’ inland transportation. It can easily connect the inland transportation to sea transportation and make the whole process more efficiently, therefore reduce the dwell time of the goods in port. Feeder management is a section under intermodal transportation with focus on the feeder network. The feeder network is a strategy which focuses on value, cost-efficiency, coverage and utilization.

Figure 1. Overview of multimodal transportation



How to strive for expanding broader economic hinterland and attracting goods resources tend to be the most concerned thing for port operators. The multimodal transport network can not only improve the capacity of harbour operation, but also contribute to the economic efficiency of the harbour. Because of that, it is necessary for a harbour to build up a network of hinterland ports.

As we know, there are two types of inland ports, one is the inland river port, and the other is inland dry port. In this case, the inland dry port has been considered as the container inland port, which has the port functions of customs, inspection and quarantine. We know that the dry port is a multimodal transport terminal which connects the harbors and hinterlands by huge quantity of transportation. Because of inland port's function, customers can deal with their goods just as they do in the harbor.

Inland container ports are usually built based on the large hinterland transport hubs (e.g. existing railway containers stations), or logistics parks. And inland ports always provide value-add service of the harbor.

Here are some typical examples of inland ports.

Virginia inland port, which located in America, has been operating from 1989. It helps Virginia port increase the market shares in the Ohio river valley area. Lyon inland port provides barge and railway wheeling service for the Port of Marseille. Mr Lo port is the inland port of Rotterdam port, which provides the consolidation and loading services to the Rotterdam port.

From these examples we can see, the inland ports actually enlarge the service of harbors and expand the range of the harbors' influential regions. Also, the functions of customs, inspection and quarantine give customers more convenience during whole transportation process.

Followings are basic functions of the inland port.

(1) Multimodal transportation.

Inland port is usually the combination point of road transportation and railway transportation. The inland port connects with the harbour through the roadway and railway. It can help transfer the goods from the harbour, change the transportation mode from sea way to railway or road way. Besides, shipping companies, shipping agencies, and goods agencies can set the embranchments at inland port in order to deliver the international goods by multimodal transportation directly, issue the multimodal bill of lading from the inland port. So that shippers can save a lot of time from booking, and insurance. The inland port provides one-stop service for containers transportation by simplify the procedures of booking, one-off payment of goods' transportation, and settlement of claims.

(2) Customs

The inland port can do land operation as same as the harbour. The inland port can directly accept the customs, inspection, and quarantine business by setting the customs office and clearance area. The goods which released by inland customs and inspection and quarantine needn't to go through the formalities again when they are arrived at the harbours.

(3) Warehousing functions

The inland port can also provide the add-value activities such as the consolidation. Moreover, it has the function as bonded warehousing. This function can improve the develop degree of inland logistics, and enhance the logistics park's agglomerate effect. It has important implications for reducing the inland logistics companies' costs. Furthermore, the inland port can also provide the logistics consulting services, and so on. In some cases the customer will request multiple loading / drop-off locations (thus turning the carrier haulage movement into an LCL (less than a container load) movement).

Different inland ports may have different functions. This should be based on the economy situations of different service regions, the different transport conditions, policy, and the degree of dependency of the harbor. According to reality of Chinese harbors' situations and the requirements of inland logistics, we can design the layout of inland ports -- we can consider the inland port as the consolidation and transferring station for the local goods.

Intermodal transportation is the portion of the total transport where the container is moved inland by truck, rail, or barge. It is the preceding or following transport leg before or after the ocean transportation by a mother vessel or feeder vessel (including the positioning of empty containers and the feeder of full containers over land)

Over-land transportation is defined as containerized cargo between two customer sites without sea transportation involved. The containers are moved over land or

inland rivers/canals only. Over-land transport is also in scope of intermodal. Inland transport is the process where a container is used to transport cargo but no ocean transportation is involved (aside from some locations that have ocean-going coastal barges)

Intermodal is arranging the physical transportation for which using modes rail, truck and barge. This can include import and export containers, the inland positioning of empty containers, the feeding of full containers over land, and over-land transport of loaded containers. Inter Terminal Transport is in scope of intermodal if the transport is carried out over public infrastructure of roads, railways or water. Otherwise it is the responsibility of the operational departments. Inter Terminal Transport moves are labeled as feeding moves.

The current scope of the intermodal process is limited to full container loads and the positioning of empty containers only. Intermodal uses the modalities truck, rail and barge to organize the transportation. The modalities can and will be combined in case this is more efficient and cost effective. And carriers arrangement should be responsible to organize the transportation and the activities on inland depots and terminal such as handlings, storage and documentation.

With the background of One Belt One Road (OBOR) policy, it becomes more crucial to learn the promotion of linked of harbors and inland ports. The network layout of linked of harbors and inland ports is fundamental for the distribution of productive forces.

And, with the development of Chinese export-oriented economy, and the range of international trade in China, the demand of inland intermodal transportation is

growing. In order to expand the port's radiation range, the port cooperates with inland governments to build up new inland ports. For example, Ningbo port had built Jinhua inland port in 2002. And in 2003, Dalian port had invited Shenyangdong inland port, which has the biggest quantity of loading and discharging of sea-rail inland transportation. Tianjin port had signed cooperation agreement with Shijiazhuang, Zhengzhou, etc. Meanwhile, Qingdao port, Lianyungang port, Shanghai port, Shenzhen port, and Xiamen port are also looking forward the cooperation with hinterlands.

Generally speaking, in China, most ports show their enthusiasm to plan and design the network of inland ports, but they still have a certain degree of blindness, and the realization of the usage of inland port is still not clear.

Following the tendency, Xiamen government now devotes itself to develop the inland ports of Xiamen, but is it suitable for Xiamen to develop its own network of inland ports? Or should Xiamen just focuses on its own harbor development and ignores the layout of inland ports? If Xiamen is suitable for developing inland ports, how to develop the network? Therefore, it is necessary of us to do the research to answer these questions.

Sea-rail combined transport in Xiamen has already been formed through long-term development, more than 10 years, but there are still a wide gap compared with other developed countries. On the basis of the survey of the network layout of linked of harbors and inland ports both in China and other countries, the thesis will give the solutions about how to develop the network between harbors and inland ports in Xiamen.

Xiamen is now developing the linked between harbor and inland ports. And the local government focuses on this. And from the condition of the researches nowadays, we can clearly know that there are few lectures about how to develop the harbor and inland ports in Xiamen. Most of the researches are the general researches.

1.2 Research Methods

In this thesis, Xiamen has been taken as a case study example to find out the relationships between harbor and inland ports. Also, the questionnaire has been made to do the research in order to draw a full picture about the real condition of the linked of harbors and inland ports. Through the feedbacks from the China's main harbors and inland ports, a picture which about the locations of the linked of harbors and inland ports in China will be drawn in order to analyze the layout of the linked of harbors and inland ports. Then, Xiamen will be taken as an example, through the method of PEST and AHP model, eventually give the solutions about how to develop the network of harbor and hinterland of Xiamen.

1.3 Frameworks and Innovation

As for the thesis framework, this thesis is divided into six chapters.

In the first chapter, the research background, methods, frameworks and innovation will be introduced. In the second chapter, a research will be taken about the layout of the network of the harbors and inland ports in both China and foreign countries. Then in the third chapter, there is an introduction about Intra and External Terminal

Transfers. After that, Xiamen will be taken as an example. The forecasting method will be used to analyze the Xiamen throughput in future. And by using the method of PEST, the way about how to improve the efficiency of Xiamen port and how to develop the network linked between Xiamen port and the inland ports will be figured out. Also, And in the fifth chapter, by using AHP model, the hinterland of Xiamen will be analyzed. And in the final chapter, the conclusion will be given with some pieces of advice.

2. Layout of the network of the harbors and inland port in China

2.1 Literature Review

As we know, the key position ports become the vital link of the logistics supply chain and the important node of the logistics system by its special location advantage and the radiation ability.

2006, Sun Guangyi and Ma Caixia use the Agent method to choose the carrier in different part of the multimodal transport. Because of the independency and interoperability of the agent, it can be used in simulation of different relationships between different mode of transportation, therefore we can find out the different advantages of different mode of transportation. Moreover, Zeng yan and Zong Peihua divided multimodal transport into three main parts: harbors, sea transportation, and inland ports systems. Based on this, they built up the synergy equation in order to do

deeper analysis. In 2008, a virtual transportation network of multimodal transport is set up by Jiang Jun and Lu Jian. Through the analysis of Chinese geographic condition, He Huawu believed that if the distance over 300km, railway transportation shows its own advantage, and the longer the distance, the more the advantages. Wang Haixia used Logit model to calculate that when the distance over 560km, railway has its merit, and when the distance less than 560km, road transportation is the best choice. What's more, Jiang Dejun used calculus method to figure out the objective correct economic distance of transportation, and provided the specific formula. Liu Jianjun and Yang Hao did a research about optimization the transport organization of the key position port through the analysis about different modes of transportation from harbor to the consignee. Through the analysis of irrational phenomena, Liu Weibin and Liu Jianyang elucidated the five factors of the rationalization of transportation.

As for the foreign researches, in order to reduce the unnecessary operation of containers in harbors, Bostel and Dejax built up a optimization model of the operation of the container yard of sea-rail multimodal transportation, and correspondent algorithms are provided. In 2000, Kozan built a model about network of transportation and then used this model into a special container harbor in order to prove that this model can be used to analysis the multimodal transportation, therefore found out the effect factors which might restrict the efficiency of multimodal transportation. In 2002, Angelica used marker method to figure out the shortest path of the multimodal transportation. But the result of this method cannot directly be used in reality, because the user still consider about fees and mode of transportation when they make the final decision. In 2004, Jansen made the point that regards harbor as the center of the container multimodal transportation, and his research was successfully used in reality. In 2004, Bethe did the research about elasticity of three

different modes of transportation: road, railway, water way. And did the calculation in the view of 10 different types of cargo, on the basis of full consideration of the gross feature of transport network, he provided a mathematic modal of transportation demand distribution. Y.H.Lun, K.-H.Lai and T.C.E. Cheng believed that the choice decision about the mode of containers multimodal transportation is complex and systematic. Though transportation fee is the main influent factor, people also consider about transport time, reliability, transport capability, degree of convenience, and safety.

Xiamen is now developing the network linked between harbor and inland ports. And the local government focuses on this. From the condition of the Chinese and foreign researches we can see, there are few lectures about how to develop the harbor and inland ports in Xiamen. Most of them are the general research.

2.2 Analysis of questionnaire

The questionnaire had been made to do the research in order to draw a full picture about the real condition of the network linked of harbors and inland ports (the questionnaire is attached in the appendices). After the questionnaire had been made, it was sent to some Chinese main harbors and inland ports. Through the feedbacks from the Chinese main harbors and inland ports, a picture about the locations of the linked of harbors and inland ports in China has been drawn.

In the questionnaire, the questions are about: the conditions of harbors and their inland ports; whether surveyors' companies cooperate with harbors or inland ports; how do inland ports connect with harbors in surveyors' places; and what do

surveyors think of the relationship between the harbor and inland ports. Also, the question about how to develop the efficiency of cooperation between harbors and inland ports had been asked.

Fortunately, most Chinese main harbors and logistics companies replied me quickly, 70 questionnaires had been sent and 67 of them been replied. The managers of main harbors and logistics companies told me about the conditions nowadays and the reality requirements of Internet usage and the attracting strategy they used to attract the cargo resources. These are very helpful for me to draw a layout of the Chinese harbors and inland ports' conditions.

Figure 2. The layout of Chinese harbors and inland ports



From this map we can see, the red points of harbors and inland ports mainly distribute in both east of China and along with the Silk Road. Also, some of them are concentrated in the middle of China such as Sichuan, Chongqing. Most of them,

which located in coastal region or streamside, have high economic levels in China.

The influential regions of harbor depend on harbor's transportation ability, handling capacity, policy support, condition of efficiency and so on. We'll discuss them in following chapters.

From this we can dimly, in varying degrees, understand the reason why our country encourage the development of One Belt One Road (OBOR) policy.

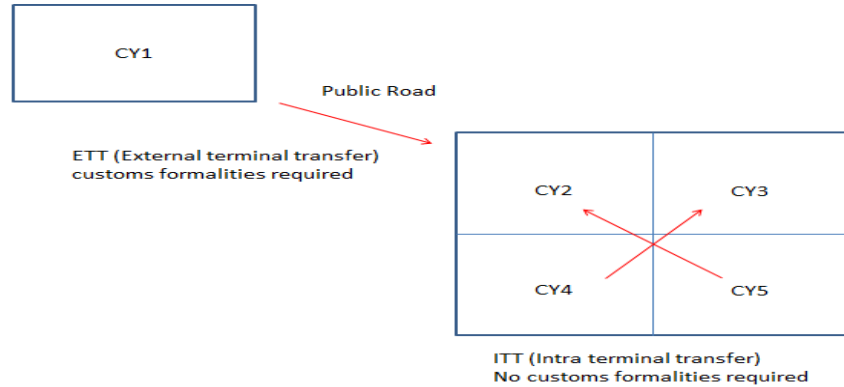
3. Intra and External Terminal Transfers

3.1 Definition

When we talk about transshipment shuttle moves, we should know that these moves can be grouped in two major categories: ITTs and ETTs.

- ITTs (intra terminal transfers) are moves that are performed across neighboring terminals, usually within a common area (box not moved on public road) that does not require customs formalities to take place.
- ETTs (external terminal transfers) are intermodal moves across deep sea port container yards or offdock container yards used that require movement of a box over public road and usually include customs formalities (please see figure below).

Figure 3. the overview of ITT & ETTs.



Inland transshipment moves are moves that occur due to the necessity to shuttle a box from one container yard to another in purpose to stack the box at a location that makes the loading of the box on the connecting vessel possible.

3.2 Different types of ITTs/ETTs execution set-ups

There are different types of ITTs/ETTs execution set-ups currently: terminal control, Liner Operations control, country operation control. The definitions are as below.

- Terminal control – this set up is mostly observed in the ITT moves. The terminal is controlling/executing or assigning the inland moves required at transshipment.
- Liner Operations control – due to the fact that Liner Operations is responsible for creating discharge list which are the main guiding principle in defining the need for ITTs/ETTs, they are also in control of planning and assigning the move to an inland operator.

- Country Operations control – this set up is mostly observed in ETT moves due to the close cooperation between country intermodal teams and intermodal vendors as well as the use of availability of intermodal system.

In sum, the discharge list of containers is the trigger to require inland movement to load/discharge.

4. Research on Xiamen port

4.1 Introduction of Xiamen Port

The Xiamen port is situated in the mouth of the Jiulongjiang River. It is an important deep water port in the southern coastline of Fujian province in China. It is one of the trunk line ports in the Asia-Pacific region. It is the 8th largest container port in China. It is the port which with the capacity to handle the sixth-generation large container vessels. On 31 August 2010, Xiamen Port incorporated the neighboring port of Zhangzhou to form the largest port of China's Southeast.

4.2 PEST analysis

From this thesis, the PEST has been used to analyze Xiamen port, and come to the

conclusion about how to develop the network of hinterlands and ports in Xiamen. The reason why using PEST instead of SWOT to analyze is that PEST analysis can analyze the external environment of the port. And SWOT can just analyze the internal environment. In this thesis, we should consider the problems from the macro-environment.

As we know, the PEST means political, economic, social and technological. These are the external environment of the port.

4.2.1 Political condition

Fujian province has abundant shoreline resources with 3,752 km mainland coastline and 2,804 km island coastline, which means Fujian province has the merits of development of huge port. By the end of 2013, the Fujian berths' throughput ability increased to 3,800,000,000 tons and 14,140,000 TEUs. And Fujian province has more than 145 thousand-ton berths, which means it has the facilities conditions of berthing large-scale marines. However, weakness still exists. Low development speed of goods volume, the imperfect harbors' public facilities, low influence and competitiveness of harbor became the barriers of Fujian ports' development.

In order to solve these problems, both Xiamen government and Fujian government published the documents.

On Aug 6th, 2014, Fujian government published the document about increasing the development speed of Fujian harbor (from 2014 to 2018).

And on Jan 16th, 2015, Xiamen government published the documents about increasing the development speed of the harbor.

Governments try their best to promote the development of core harbors and focus on creating the core areas which contain the container shipping port (Xiamen and Fuzhou) and the bulk port (Luoyuan and Meizhou). Until 2018, the government total investment of harbors' network building will increase to 48 billion yuan to build the large deepwater assets construction and upgrading the terminal. The new deep water berths will add to 55, and the throughput capacity will grow up to 220 million tons. Fujian province will form eight large-scale, intensive, professional core areas.

4.2.2 Economics development

Since the reform and opening (year 1978), Xiamen's industry growing dramatically. Especially nowadays, the increasing rate of Xiamen industry grows steadily and this provide a good foundation of Xiamen's industrial transformation and upgrading.

According to the status from Xiamen bureau of statistics, by the end of 2013, the production output of manufacturing of transportation was up to 34.04 hundred million.

Increasing of value of industry speeds up the industry's integration. Most industry parks move out the Xiamen island, therefore the Xiamen industry layout has been optimized. And because of this, building an efficient logistics park seems necessary.

4.2.3 Social condition

Based on the modern seaport, in order to increase the efficiency of harbor, promote the shipping elements agglomeration and maritime silk road construction, Xiamen is planning to build the continent logistics net which covers the both sides of the Taiwan Straits, connects the inlands, and faces all over the worlds.

Thanks to the shipping talents information platform, Xiamen has already had large number of people who contribute themselves to the shipping industry.

Moreover, from long time ago, Xiamen is already a port for fishing, which means Xiamen people has the sense of maritime. And the social common sense is helpful if a city wants to develop maritime industry.

Xiamen has a large stretch of hinterland. Jiangxi, Jinjiang, Longyan, Sanming, and so on. Theses hinterland ports expend the port functions of the harbour – just as the thesis mentioned before.

Not only the hinterland, if Xiamen wants to expand its scope of radiation, it should also extend the range of feeders. According to the “benefit sharing” rule, Xiamen can create the feeder network which extends from Wenzhou to Shantou. Also, Xiamen can develop the strategic feeder network of Putian, Quanzhou, Dongshan, and Shantou. According to the Xiamen government report, by the end of 2018, Xiamen can grow as the main access and terminal of central and western provinces of goods in and out of Taiwan.

4.2.4 Technological condition

Relying on the fujian transport logistics public information platform, Xiamen is creating the advanced port logistics information platform, it can help the port logistics informatization. And this makes the port's unified declaration and information sharing possible. And the cold chain logistics information platform also helps create the creation of logistics centre of east and south China and Taiwan region.

4.3 Forecasting method analysis

In this part, the forecasting method has been used to analyze the Xiamen throughput in future. The data of Xiamen port was given by Xiamen port authority, and then the Double Exponential Smoothing Method has been used to forecast the future 20 year's Xiamen port throughput. This method has been chosen instead of Yearly Average Growth Rate (YAGR) because the port throughput is a time series data, and Double Exponential Smoothing Method is more accurate which could reflect the situation when there was a trend in data. Double Exponential Smoothing Methods is given by the formulas.

$$\begin{aligned}S_t^{(1)} &= \alpha y_t + (1 - \alpha) S_{t-1} \\S_t^{(2)} &= \alpha S_t^{(1)} + (1 - \alpha) S_{t-1}^{(2)} \\Y_{1+T} &= a_t + b_t T \\a_t &= 2 S_t^{(1)} - S_t^{(2)} \\b_t &= \alpha / (1 - \alpha) * (S_t^{(1)} - S_t^{(2)})\end{aligned}$$

$S_t^{(1)}$ to represent the smoothed value of time t , and $S_t^{(2)}$ was the smoothed value of double exponential smoothing of time t . Both a_t and b_t were parametric variables. And Y_{1+T} was the linear prediction of parametric variables. T was the forecast period from time t . α was the smoothing factor.

Because the throughput of Xiamen port showed a relevant rapid change between 2005 and 2014, in order to make forecasting model more sensitive, the value of α was a range between 0.6 and 0.8. And $\alpha=0.6, 0.7, 0.8$ had been used to forecast the $S_t^{(1)}$, and calculated the MSE each of them. And MSE was the smallest when $\alpha=0.8$, so $\alpha=0.8$ has been decided as the value of the smoothing factor.

And the results as following:

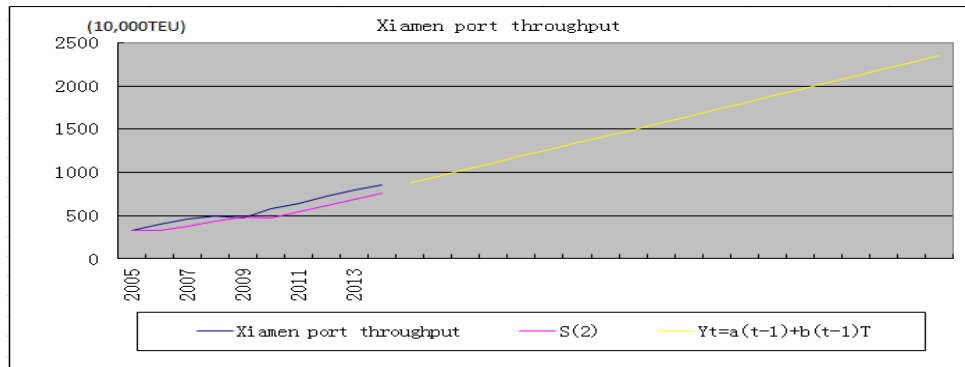
Table 1. Forecasting model of Xiamen throughput (10,000TEU)

		0.6	0.7	0.8				
	Xiamen port throughput	forecast value (weight move average)0.6	forecast value (weight move average)0.7	forecast value (weight move average)0.8 $s(1)$	$S(2)$	a	b	$Y_t=a(t-1)+b(t-1)T$
2005	334.2	334.2	334.2	334.2	334.2	334.2	0	
2006	401.3	334.2	334.2	334.2	334.2	334.2	0	
2007	462.7	374.46	381.17	387.88	377.144	398.616	42.944	
2008	503.4	427.404	438.241	447.736	433.6176	461.8544	56.4736	
2009	468	473.0016	483.8523	492.2672	480.53728	503.99712	46.91968	
2010	582.4	470.00064	472.75569	472.85344	474.390208	471.316672	-6.147072	
2011	646.5	537.440256	549.506707	560.490688	543.270592	577.710784	68.880384	
2012	720.1	602.8761024	617.4020121	629.2981376	612.092628	646.5036467	68.82203648	
2013	800.7	673.210441	689.2906036	701.9396275	683.970228	719.9090273	71.87759923	
2014	857.2	749.7041764	767.2771811	780.9479255	761.552386	800.3434651	77.58215823	
2015							1	877.9256233
2016	MSE	95239.13905	84555.18419	75788.65976			2	955.5077815
2017							3	1033.08994
2018							4	1110.672098
2019							5	1188.254256
2020							6	1265.836414
2021							7	1343.418573
2022							8	1421.000731
2023							9	1498.582889
2024							10	1576.165047
2025							11	1653.747206
2026							12	1731.329364
2027							13	1808.911522
2028							14	1886.49368
2029							15	1964.075839
2030							16	2041.657997
2031							17	2119.240155
2032							18	2196.822313
2033							19	2274.404472
2034							20	2351.98663

Double Exponential Smoothing Methods had been used to forecast the throughput of Xiamen port between 2015 and 2034, and the yearly average growth rate (YAGR) of

these forecasted data was 5.32%, which means the throughput of Xiamen will grows sustainably.

Figure 4. Xiamen port throughput forecasting



However, growing throughput will become a burden for Xiamen island itself. As we know, in China, especially for containers, the volume of import is far less than export. What's more, in Xiamen island, there are not that much factories to provide the goods for export – most of factories are moved outside the island. So, expanding the radiation region, hinterland, is necessary.

5. Hinterlands analysis

5.1 Introduction of hinterland situation

As we know, again, in general, merchant haulage implies that the inland transportation is arranged directly between the shipper and the vendor, whereby the

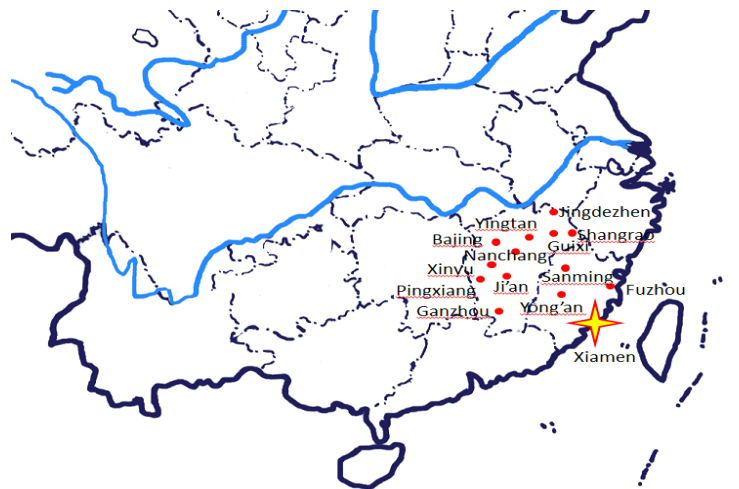
vendor charges the shipper directly.

3rd Party instructions are all instructions where no inland transportation charges are collected by the ordering party. The ordering party can be a shipper, a company, or the shipping line agent. When sent by a shipper, the intermodal department is ordered to arrange transport whereby the costs including an eventual mark-up to the shipper, a company, or the shipping line agent directly.

As the thesis mentioned before, hinterland dry port, as the container inland port, which has the port functions of customs, inspection and quarantine. Inland ports are the explanations of the harbor.

From my research, a picture of Xiamen layout of the harbor and inland port has been drawn as following:

Figure 5. The layout of the harbor and inland port of Xiamen



The location where marked by yellow star is Xiamen, and the red dots are some inland ports of Xiamen. From the picture we can see, the scope of Xiamen port's

radiation region expands to the northwest, and most inland ports of Xiamen concentrated in Jiangxi Province.

Here are some throughput data of the Xiamen's hinterland:

Table 2. The volume of multimodal transportation in Xiamen (TEU)

	2010year	2011year	2012year	2013year	2014year
Nanchang	7882	8375	5544	2701	2408
Bajing	-	181	3474	1648	510
Ganzhou	3764	7640	3237	4673	4214
Ji'an	2771	2666	1950	2256	2074
Xinyu	34	1391	1859	369	415
Pingxiang	-	1521	1913	420	46
Guixi	2596	2640	1640	1142	702
Shangrao	102	106	6	36	0
Jingdezhen	460	174	42	0	0
Yingtian	408	380	676	794	996
Sanming	4799	4961	5327	4613	5089
Fuzhou	-	322	0	0	0
Others	386	1147	3557	1964	420
TOTAL	23407	31676	29229	20616	16874

(According to the data from Xiamen port authority)

And the percentage of each hinterland's throughput has been calculated. And the results are follows:

Table 3. The percentage of each hinterland's throughput(1)

	2010year	2011year	2012year	2013year	2014year
Nanchang	33.67%	26.58%	18.97%	13.10%	14.27%
Bajing	-	0.57%	11.89%	7.99%	3.02%
Ganzhou	16.08%	24.25%	11.08%	22.67%	24.97%
Ji'an	11.84%	8.46%	6.67%	10.94%	12.29%
Xinyu	0.15%	4.42%	6.36%	1.79%	2.46%
Pingxiang	-	4.83%	6.55%	2.04%	0.27%
Guixi	11.09%	8.38%	5.61%	5.54%	4.16%
Shangrao	0.44%	0.34%	0.02%	0.17%	0.00%
Jingdezhen	1.97%	0.55%	0.14%	0.00%	0.00%
Yingtian	1.74%	1.21%	2.31%	3.85%	5.90%
Sanming	20.50%	15.75%	18.23%	22.38%	30.16%
Others	1.65%	3.64%	12.17%	9.53%	2.49%
TOTAL	100.00%	100.00%	100.00%	100.00%	100.00%

(According to the data from Xiamen port authority)

Some of the data has been picked up for analysis. Nanchang, Guangzhou, Ji'an, Sanming had been chosen as examples to analyze. All of them are good choices because all of them showed the upward trend from 2012 to 2014. Moreover, these four sites occupied larger share than others of the hinterland's throughput, which means they are typical.

Table 4. The percentage of each hinterland's throughput(2)

	2010year	2011year	2012year	2013year	2014year
Nanchang	33.67%	26.58%	18.97%	13.10%	14.27%
Ganzhou	16.08%	24.25%	11.08%	22.67%	24.97%
Ji'an	11.84%	8.46%	6.67%	10.94%	12.29%
Sanming	20.50%	15.75%	18.23%	22.38%	30.16%
TOTAL	82.10%	75.04%	54.95%	69.09%	81.69%

(According to the data from Xiamen port authority)

In my opinion, if the government wants to develop all the hinterlands, compared with develop them in the same time, focusing on one site one time could be a better choice. Because once the inland port's functions matured, it can contribute the experience about how to develop inland port to other sites. And this can save lots cost of money and time.

5.2 AHP model

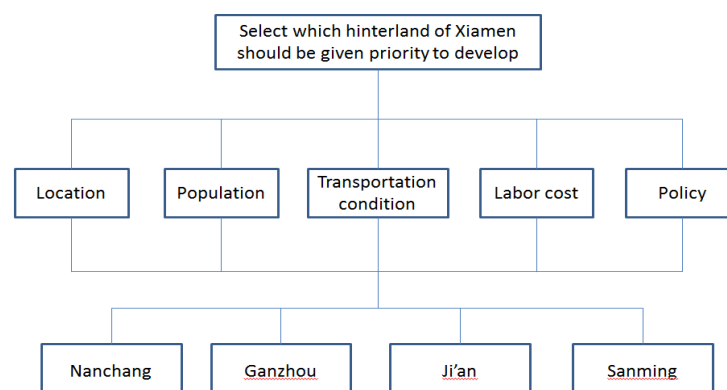
In this case, we have four sites as alternative offers, they are Nanchang, Ganzhou, Ji'an, Sanming. From the research we know that location, population, transportation, the cost of labor, and policy are relevant with the inland port development. Therefore,

the government should make a decision about choosing among the cities by determining how well each location meets the following five criteria: location, population, transportation, the cost of labor, and policy. As for developing the inland ports, if Xiamen government wants to develop the hinterland, the government should choose one site to give support and attention. And once one hinterland matured, government can copy its experience to develop other hinterlands, so that we can save lots money and time

In this case, AHP model has been chosen to analysis the hinterland situation because AHP model is a method which using people's experience and judgment to make decision. AHP model helps decision makers find out the best choice which suits their goal and the understanding of the problem. About choosing the sites, it is not a "correct or not" decision, it all about choosing a site which can suits our goal – to be the priority develop hinterland so that can prove experience for other inland ports.

The AHP model structure is as following figure.

Figure 6. The AHP model structure



Firstly, we should build pairwise comparison matrices. A questionnaire about the importance of these five criteria in port network development (the questionnaire is attached in the appendices) had been made, and had been sent to some professional people to evaluate these five criteria and determine the scores of each alternative on each criterion. The structure of investigation sample is as following: 4 of them are teachers in Jimei University -- 2 of 4 are professors; 3 of them are officers of Xiamen port authority; and there are 9 senior salesmen who were asked for these questions -- 4 of 9 from Xiamen local trade companies, 3 of 9 from Ji'an, and the rest 2 are salesmen from Ganzhou; also, questionnaires had been sent to 3 managers in shipping agency companies.

From their opinions, location is slightly more important than population because location is the base of the convenience of logistics. And obviously, for a hinterland distribution terminal, transportation condition is as important as location because transportation condition can influence the speed of logistics. Another criterion is the cost of labor, because if you want to build infrastructure, the cost of labor is a matter of concern. As for policy, it can promote the inland port build, but compared with location, it is not that important.

Also, they believed that the population influence more than the cost of labor when we make the decision of location choice. As we know, for an inland terminal, market size is of importance, because the bigger market size, the more potential market share. And the same conclusion also appeared when we compared the population and the policy because the project evaluation of market size is an important factor for decision making of inland port construction.

Compared transportation condition and population, these experts suggested that the

transportation condition influence the choice of hinterland distribution center more. As we all know, a local transportation condition is the foundation of evaluate the speed of logistics, transportation condition is more vital than the cost of labor because a very fluent transportation condition can transit more goods so that can make more money which may cover some cost of labor. And compared transportation condition and policy, the experts argued the transportation condition is slightly more important than policy because transportation condition influence logistics more. And they suggested that the cost of labor and policy are equally important.

After compared five criterions and analysis the feedbacks, we can build pairwise comparison matrices as following:

A	location	population	transportation condition	cost of labor	policy
location	1	3	1	3	5
population	1/3	1	1/3	3	3
transportation condition	1	3	1	3	3
cost of labor	1/3	1/3	1/3	1	1
policy	1/5	1/3	1/3	1	1

Then we can normalized pairwise comparison matrices A to get A*. And after that, estimate the weight for criterions, and the functions are follows:

$$a_{ij}^* = \frac{a_{ij}}{\sum_{i=1}^n a_{ij}}$$

Aij*	location	population	transportation condition	cost of labor	policy
location	1/3	2/5	1/3	1/4	2/5
population	1/9	1/8	1/9	1/4	1/4
transportation condition	1/3	2/5	1/3	1/4	1/4
cost of labor	1/9	0	1/9	0	0
policy	0	0	1/9	0	0

$$W_i = \frac{\sum_{j=1}^n a_{ij} *}{n}$$

And we can gain the results as follows by using Excel:

w1	0.346164
w2	0.172264
w3	0.315394
w4	0.08774
w5	0.078438

Next, we should check for consistency.

(1) compute AW

$$AW = A * \begin{bmatrix} w1 \\ w2 \\ w3 \\ w4 \\ w5 \end{bmatrix} = \begin{bmatrix} 1.83376002 \\ 0.89131731 \\ 1.67688442 \\ 0.44411861 \\ 0.39896348 \end{bmatrix}$$

(2) calculate λ_{\max}

$$\lambda_{\max} = \sum_{i=1}^n \frac{(AW)_i}{nW_i} = 5.184733$$

(3) compute the constancy index CI.

$$CI = \frac{\lambda_{\max} - n}{n - 1} = \frac{5.184733 - 5}{4} = 0.04618325$$

(4) compute the constancy ratio CR.

$$CR = \frac{CI}{RI} = \frac{0.04618325}{1.12} = 0.04123504$$

Because $CR < 0.10$, then the degree of consistency is satisfactory.

After those steps, we could determine the scores of each alternative on each criterion.

5.2.1 Location

According to a lot of introduction materials, we know that Ganzhou is situated in the southern part of Jiangxi province, bordering Fujian province to the east. Ganzhou is a large with 39,400 square kilometres in area, and more than 70% of its administrative area covered by forests, and over 83% is mountainous. And Ganzhou is along with the Gan River.

Nanchang is the capital of Jiangxi Province in southeastern China. It lies in the north-central part of the Jiangxi province. Jiuling Mountains are situated at the west corner of Nanchang, and Boyang Lake is located at the east corner. Because of its strategic location, connecting the prosperous East and South China, Nanchang has become a major railway hub in Southern China in recent decades. Nanchang is 130 km away from the Yangtze River and is situated alongside the Gan River.

Ji'an is a prefecture-level city in Jiangxi province with 25,219 kilometers in area. Ji'an is located on the western border of Hunan province, on the northern border of Yichun City, the south border of Ganzhou City.

Sanming is a prefecture-level city in western Fujian province. It lies on the northern border of Nanping City, the eastern border of Fuzhou city, the southeastern border of Quanzhou City, the south border of Longyan City, and the western border of Jiangxi province. Sanming lies between Wuyi and Daiyun mountains. Sanming is 22,928.8 square kilometres in area and 82% of Sanming covered by mountainous areas.

5.2.2 Population

Until 2010, Ganzhou's population was 8,361,447 with 1,977,253 people lived in the metro area. As for Nanchang, in 2010, 5,042,566 people lived in the prefecture. Ji'an had a population of 4,810,339 and 538,699 of them live in the metro area. According to the 2010 Census, Sanming has a population of 2,503,338 -- 70,687 inhabitants less than in 2000 Census, and the average annual population growth for the period 2000-2010 was of -0.28%.

5.2.3 transportation condition

Ganzhou had abundant of transportation resource: China National Highways (G 105, G 206, G 319, G 323.) and Ganyue Expressway go across Ganzhou. And the Beijing-Jiulong Railway goes through Ganzhou from north to south, and it meets the Ganzhou–Longyan Railway (Ganlong line) at East Ganzhou Railway Station in Zhanggong Distrcit.

Nanchang is an important rail hub for southeastern China. The Beijing–Kowloon (Jingjiu) Railway, Shanghai–Kunming (Hukun), Xiangtang–Putian Railway and Nanchang–Jiujiang Intercity Railway converge in Nanchang. Also, Nanchang is connected to Hangzhou, Changsha and Shanghai via CRH (China Railway High-speed) service. The road transport infrastructure in Nanchang is extensive. A number of national highways cross through the city: National roads No.105 from Beijing to Zhuhai, No.320 from Shanghai to Kunming, and No.316 from Fuzhou to Lanzhou.

The road transportation net in Ji'an is good. Jingjiu railway and some national highways cross through the city. Ji'an is along with the Gan River, and connects with Yangtze River and Boyang Lake through Gan River.

Sanming also has convenient transportation, but as the thesis mentioned above, there are about 82% of Sanming covered by mountainous areas.

5.2.4 Labor cost

It's hard to find out the direct data of the labor cost, but according to the economic development and consumption level, those experts gave the scores.

5.2.5 Policy

In order to develop the hinterland, Xiamen government and Ganzhou government signed the cooperation agreement. And the government encourages Ganzhou to develop hinterland business. Government encouragement always has guidance effect.

The first Xiamen-Ganzhou port cooperation project of Xiuyu port area is located in Meizhou Bay, and it is planned to operate in the late 2015. This project will built a 300,000 square meters oil depot with 50,000 tons petrochemical wharf, 141,500square meters capacity of the tank, special railway and loading/unloading filed. It will cost 600,000 yuan. This project will make the port and hinterlands' resources of Xiamen and Ganzhou complementary to each other, and it will strengthen industrial docking of Xiamen and Ganzhou, promote the mutual benefit and win-win results.

5.2.6 Result

After evaluated location, population, transportation, the cost of labor, and policy, experts gave all the scores of five elements of different cities. Scores' range is from 1 to 5, which means the different degree of same element condition.

All the scores are listed in following table:

	Nanchang	Ganzhou	Ji'an	Sanming
location	4	4	4	5
population	3	4	2	1
transportation condition	4	5	4	3
labor cost	2	1	4	3
policy	1	5	1	1

At last, Excel had been used to calculate an overall score for each city, and determine the best alternative.

	score
Nanchang	3.416942074
Ganzhou	4.130611709
Ji'an	3.420158024
Sanming	3.19092284

From the results we can see, Ganzhou gained the highest score while Sanming gained the lowest score.

From the results we can clearly know that, Ganzhou gained the highest score. From the above article we know that Nanchang, Ganzhou, Ji'an, and Sanming are all great alternative to be inland port of Xiamen. But if Xiamen government wants to support on site priority – let's say, support one site for more efficiently – Xiamen government should choose Ganzhou to support.

6. Solutions & Conclusion

6.1 Existing problems

Though we talk a lot about Xiamen and its hinterlands' good locations, policies, and so on, there is a tough problem we cannot ignore it. Just as table 5 showed below, the percentage of multimodal transportation of total throughput in Xiamen port is really low – no more an 1%.

Table 5. The percentage of multimodal transportation of total throughput in Xiamen

	total throughput in Xiamen port(TEU)	multimodal transport(TEU)	Percentage(%)
2010	5824000	23407	0.40%
2011	6465000	31676	0.49%
2012	7201000	29229	0.41%
2013	8007000	20616	0.26%
2014	8572000	16874	0.20%

(According to the data from Xiamen port authority)

Xiamen has been developing multimodal transportation for more than 10 years, but the percentage of multimodal transportation is still low. How can we deal with this? Developing multimodal transportation, we cannot just shout slogans, we should exactly figure out what's going wrong.

We know that multimodal transportation refers to several methods: waterway, railway and road. In Xiamen, the asset and the port equipment are high-level because the government invest a lot of money to upgrade them. But we also know that if we want to develop the multimodal transportation, we should also pay attention to the

railway structure. Because railway has high capacity to transport, and compared with the road transportation, it shows cost advantage in long distance transportation. Therefore, the railway is vital because it can connect hinterlands and harbor effectively and efficiently.

Fujian is a mountain area. In order to give you intuitive feeling, a topographic map of Fujian province has been put below. The red circle is the location where Xiamen is. As you can see from the map, most areas of Fujian province are mountains, and this brings an obstacle to building the railway network and limits the convenience of transportation.

Figure 7. The topographic map of Xiamen



Because of the weakness of the railway and inconvenient railway network, most multimodal transportation in Xiamen is by road. Of course road transportation is more flexible than railway transportation, but the capacity is relatively low and the transportation distance is relatively short. This means that if we choose roadway as Xiamen's main mode of multimodal transportation, the radiation region has its own limit, and the turnaround efficiency will be low.

Also, the increasing of railway transportation cost is another problem which Xiamen facing. In 2014, the cost of railway transportation increased 12% -- grew up by 1 cent per kilometers.

Moreover, there is still a problem of the intermodal transportation in Xiamen. That is the problem of standard container. Because the standard container of railway has different size from standard container of seaway, if Xiamen wants to develop high-level multimodal transportation and increase multimodal transport efficiency, the government should consider about how to deal with this problem.

From long ago, not only in Xiamen, but also in China, we have different department to manage different mode of transportation: waterway and road are managed by Ministry of Communications; the railway is managed by Ministry of Railways. Therefore, because of lack of the efficient communication, different department cannot cooperate fluently, so that cannot organize the multimodal transportation effectively. It's hard to build up a mature network of intermodal transportation in this situation. The efficiency of goods multimodal transportation will be limited until this structural problem be solved.

With the development of technology, people realized that we need a united

information platform to support the multimodal operation system. Multimodal transportation refers to different transportation mode, different parties and consumers. Because the requirement from the clients change rapidly, it is hard to reach the target of intermodal transportation without a firm, reliable technology platform. Though in Xiamen, intermodal information system platform is built initially, and the EDI system came into use, this kind of information system is not in general use. What's more, lack of tracking technology is also a problem. The harbor, the shipping companies, and the agents still not sharing information to each other, which makes the lag of information transfer.

Furthermore, the hinterland goods resources have strong competitions. Because of the crossing of hinterland, Shanghai International Port Co., Ltd transports their goods by feeders through Yangtze River to Shanghai port – this kind of inter water transportation can save more money than sea-rail transportation, and the low cost help Shanghai port seize the market. Take Nanchang as an example, it can save 2,000 yuan/TEU by using inter water transportation rather than using sea-rail transportation. Therefore, Xiamen should get a steady and large amount of source of goods in order to win in the fierce competition, and government can increase the subsidies to sea-rail transportation to attract more goods sources.

As for most inland ports of Xiamen, because of the narrow area of container yard, the capacity of stock is limited. And incomplete drainage facilities of inland ports result in ponding during the heavy rain, which will soak the containers and may damage the inside cargo.

Container inspection, goods examination, colligation required complicated procedures, and the complicated procedures will lead time consumption. And

because of the low degree of development, most of inland container terminals have limited in transition and lightering operations.

6.2 Solutions

From the PEST analysis, we can clearly know that Xiamen is a good center of network of harbor and inland ports not only its good location, but also its political, economic, social, and technologic conditions. Therefore, Xiamen is the good linked between harbors and inland ports. Moreover, the national strategy “build the marine silk road” gives Xiamen a good opportunity to develop intermodal transportation.

Using this good opportunity is a really challenge for Xiamen because if Xiamen can take this opportunity to develop its multimodal transportation, therefore Xiamen can have chance to become the logistics center of east and south China and Taiwan region. So, some pieces of advice about how to use this good opportunity effectively and efficiently are given.

Infrastructures should always be priority. As the thesis mentioned before, most existing problems are caused by incomplete infrastructures – not only of linked between the harbor and inland ports, but also of inland container terminals.

Monitoring plays an important role. Monitoring is a process which should continuously be performed during the overall process. This includes both the internal as external processes. Service failures can occur in all parts of the process and should be identified as soon as possible.

Service failure is an event occurring during the execution of the work order which influences the normal and expected work flow. Service failure can be caused by different parties in the process and can have a negative impact on the service and/or the costs.

A Service failure can result in additional charges from the vendor. The description of the Service failure and the related charges must be communicated to the ordering party in writing.

Service failure should be evaluated and be part of the vendor performance measurement and it should always be documented and archived.

The preferred transport mode must be advised by the ordering party to intermodal. The ordering party makes agreements with the end customer how the container will be transported. Therefore the transport mode should always be part of the transport order. A container can be transported by using more than 1 transport mode before it reaches its final destination. Optimization is the intermodal process where the dispatcher is searching for the best possible and most cost efficient execution of the transport orders respecting the requirements from customer service, equipment and the customers.

Firstly we should enhance the maritime cooperation with the countries which alongside Marine Silk Road. And encourage the ports and logistics companies take part in the strategic investment in foreign countries. The ports and logistics companies should work together to invest, develop, build, manage and operate the ports and assets, to promote port alliance among countries, so that we can extend the Marine Silk Road.

Secondly, to explore the develop mode of Taiwan goods via Xiamen transit to south-east Asian nations. Xiamen can attract the Taiwan goods to do transit through using preferential tariff policy of the association of southeast Asian nations. And through the cooperation with Guangxi Qinzhou port, Xiamen can open up the new channel to the Southeast Asian nations.

Thirdly, Xiamen should expand the hinterland area, accelerate the construction of port transportation system. Though Xiamen has a good start of multimodal transportation, yet the percentage of multimodal transportation of total container throughput is really very low – which less than 1%. If Xiamen wants to develop the multimodal transportation, we should build up the distribution terminal first and make up the multimodal transportation rule, in order to increase the degree of concentrated. Nowadays, multimodal transportation maintains a good momentum of development, to product the good result, every relative department, companies should cooperate tightly. Also, government should enhance the supervision.

Fourthly, the integration of intermodal transportation needs integration infrastructure. In order to realize the seamless docking of different mode of transportation, we should integrate the existing logistics equipment, and make a plan about building logistics parks. Meanwhile, we should try our best to extend and expand the radiation region by railway and roadway. Providing individual logistics plan by realizing source concentration.

Fifthly, technology information is everything. Xiamen already has the united information platform. It is really a good try because it makes multimodal transportation seamless docking possible, so that increase the efficiency of

intermodal transportation. The Xiamen government should enhance the efficiency of information exchange among harbor, inland, and shipping companies. And the government should improve the service quality by providing customers as much information as they want. And railway, roadway, and waterway should cooperate seamlessly in order to complement each other's advantages and mutual benefit and win-win result.

Sixthly, we should defined the container's movement – export, import, feeder, positioning -- and this can help us to illustrate the condition of containers.

Feeder includes ITT moves over public infrastructure but not including foreign feeder or sea feeder moves.

Positioning means empty container moves between regions equipment depots

What's more, as the thesis mentioned above, container tracking is crucial. The exact definition help us to know exactly where the container is and what is the container's condition. The better we can track the whereabouts of a container the better we can manage and control our process and costs involved. Therefore, Track and Trace functionalities should be incorporated into the intermodal process to the highest extent possible. Track and Trace can be used to notify delays.

Moreover, in order to improve the service level of multimodal transportation, cut off times and ETA (Estimated time of arrival) should always be checked and it must be ensured that they do not conflict with the execution of the order. ETA is the date and time the mother vessel or feeder will arrive at the port of discharge and after which the import cargo is available for final delivery to the customer and this data is

supplied by the terminal operations on a daily basis. Cut off times and ETA could be applicable for rail and barge operations as well. Cut-off Date and time is the time that the loaded export containers must be back in the load port for loading on the mother vessel or feeder and this data is supplied by the terminal operations on a daily basis. The cut off date and time and the vessel ETA should be advised to the intermodal department and should therefore be part of the transport order.

Furthermore, documents. Any local requirements and procedures regarding the custom documentation and other documentation are to be followed. The ordering party must advise the Intermodal department of any documentation requirements via the transport order. The documents requirements must be checked.

Also, the government should introduce Xiamen intermodal transportation to more shippers, and sign the cooperation agreement in order to expand the business share.

6.3 Conclusion

From the thesis we can see, Xiamen has many inland ports, for example, Nanchang, Bajing, Ganzhou, Ji'an, Xinyu, Pingxiang, Guixi, Shangrao, Jingdezhen, Yingtian, Sanming, Fuzhou, and so on. And 4 of them are main hinterland ports of Xiamen. They are: Nanchang, Ganzhou, Ji'an, and Sanming. From the AHP model, it is reasonable that Ganzhou should be paid more attention to develop priority.

After that, the existing problems had been pointed out and some pieces of advice had been given. These pieces of advice could help Xiamen develop its network between the harbor and inland ports.

In sum, the development of network between Xiamen port and hinterlands is not only a challenge, but also a chance to increase the city's maritime reputation. And a complete network can help Xiamen develop to be an international port city.

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Appendices

Appendix 1

Research on Xiamen port network layout from the perspective of harbors and inland ports linked development Questionnaire (1)

(Please fill in the name of inland port/ Logistics Company)

Dear all,

Hello, I am a postgraduate student in World Maritime University. I am now doing a research on Xiamen port network layout from the perspective of harbors and inland ports linked development for my thesis.

Please help me answer following questions and send this questionnaire back to me.

Thanks for your cooperation.

1. Please introduce the condition of inland port/logistics company. (e.g. location, business condition, policy limited, and so on.)
2. Do your company cooperate with harbor or inland port?

3. How do inland port connect with harbor in your place?
4. What do you think of the relationship between the harbor and inland ports?
5. What do you think about how to develop the efficiency of cooperation between harbors and inland ports?

Appendix 2

Research on Xiamen port network layout from the perspective of harbors and inland ports linked development Questionnaire (2)

Dear all,

Hello, I am a postgraduate student in World Maritime University. I am now doing a research on Xiamen port network layout from the perspective of harbors and inland ports linked development for my thesis.

From my previous study, I strongly believe location, population, transportation, the cost of labor, and policy are relevant with the inland port development. As for developing the inland ports, I suggest that if the Xiamen government wants to develop the hinterland, the government should choose one site to give support and attention. And once one hinterland matured, government can copy its experience to develop other hinterlands, so that we can save lots money and time.

In this case, I chose four sites as alternative offers, they are Nanchang, Ganzhou, Ji'an, Sanming. Please help me mark following elements and send this questionnaire back to me.

Thanks for your cooperation.

(1) Please mark the importance of following elements:

1 -- equally important

3 -- slightly important

5 -- important

7 -- obviously important

9 -- absolutely important

	location	population	Transportation condition	Cost of labor	policy
Location					
Population					
Transportation condition					
Cost of labor					
Policy					

(2) Please evaluate the degree of following five elements' conditions of different cities. Scores' range is from 1 to 5.

1 – weak 2 – slightly good 3 – good 4 – obviously good 5 – absolutely good

	Nanchang	Ganzhou	Ji'an	Sanming
Location				
Population				
Transportation condition				
Labor cost				
Policy				